

Contents

Preface vii
To the Student ix

Chapter

1 Methods of Scientific Investigations 1

Objectives 1
An Hypothesis Analyzed by Observation 1
An Hypothesis to be Analyzed by Experimentation 5
An Hypothesis to be Analyzed by Correlated Variation 6
Preparation of Materials 8

Chapter

2 The Microscope 9

Objectives 9
Care and Use of the Compound Microscope 9
Examination of Microorganisms in Pond Water 13
Demonstration of Depth of Field 14
Additional Suggestions about Microscope Use 15
Other Types of Microscopes 16
Preparation of Materials 18

Chapter

3 The Chemistry of Life 19

Objectives 19
Organic and Inorganic Compounds 19
The Nature of Dispersion Systems in Water 20
Crystallography 23
Emulsifiers 24
Identification of Organic Compounds 25
Effect of pH Value on Growth of Microorganisms 29
Preparation of Materials 31

Chapter

4 Enzymes 33

Objectives 33
Peroxidase, an Intracellular Enzyme 33
Effect of pH on Pepsin and Amylase 34
Effect of Temperature on Enzyme Action, Rennin and Proteinase 36
Preparation of Materials 37

Chapter

5 The Eukaryotic Cell 38

Objectives 38
Anarcharis Leaf Cells 38
Epidermal Cells from the Human Mouth 41
Prepared Slides of Cells 43
Cell Duplication—Mitosis 43
Meiosis, the Reduction in Chromosome Number 47
Preparation of Materials 50

Chapter

6 Movement of Materials in Living Organisms 51

Objectives 51
Diffusion of a Solid in Water 51
Diffusion Through a Membrane 52
Diffusion in a Solid 52
Demonstration of Molecular Movement 53
Osmosis 54
Plasmolysis of Cells 55
Effect of Variations in Osmotic Pressure on Red Blood Cells 56
Active Transport Through Living Membranes 58
Preparation of Materials 59

Chapter	7	Energy Transformation in Living Organisms 60	Chapter	11	The Fungi 96
		Objectives 60			Objectives 96
		The Necessity of Light for Photosynthesis 60			Slime Molds 96
		The Necessity of Carbon Dioxide for Photosynthesis 61			Bread Mold— <i>Rhizopus</i> 98
		The Necessity of Water for Photosynthesis 62			Yeast— <i>Saccharomyces</i> 101
		The Necessity of Chlorophyll for Photosynthesis 63			A Mushroom 102
		Separation of Chlorophylls and Other Leaf Pigments by Paper Chromatography 63			Other Fungi 103
		The Production of Oxygen During Photosynthesis 65	Chapter	12	Plants without Seeds 104
		Photosynthetic Efficiency of Different Colors of Light 66			Objectives 104
		Carbon Dioxide Production in Respiration 67			A Liverwort 104
		Anaerobic Respiration 69			A Moss 107
		Preparation of Materials 72			A Fern 109
Chapter	8	Taxonomy, the Classification of Living Things 73	Chapter	13	The Seed Plants 112
		Objectives 73			Objectives 112
		The Dichotomous Key 73			The Pine 112
		Use of an Insect Dichotomous Key 74			A Flower 115
		Making a Dichotomous Key 76			Fruits 116
		Characteristics of the Classes of Vertebrates 76			Seed 118
		Classes of Vertebrates 76	Chapter	14	Structure of Higher Plants 119
Chapter	9	The Monera—Prokaryotic Organisms 79			Objectives 119
		Objectives 79			Root System of a Young Seedling 119
		The Cyanobacteria 79			Cross Section Through Mature Region of Young Root 120
		The Bacteria (Eubacteria) 81			Structure of an Herbaceous Stem 121
					Structure of Young Woody Stem 122
					Structure of Mature Woody Stem 124
					Woody Stem 125
					Monocotyledon Stem 126
					Structure of a Leaf 128
					Leaf Diversity 129
Chapter	10	The Protista 86	Chapter	15	Plant Response to Environment 133
		Objectives 86			Objectives 133
		Spirogyra 86			Homeostatic Regulation of Gas Exchange in Leaves 133
		Fucus 87			Homeostatic Response of Seedlings to Gravity 134
		Other Algae 89			Water Transport in Higher Plants 137
		Amoeba—a Protozoan 89			
		Paramecium 91			
		Other Protozoa 94			
		Preparation of Materials 94			

Hormone-Induced Response of
Stems to Light and Gravity 139
Hormone Stimulation of Root Growth
141
Effect of Gibberellic Acid on
Seedling Growth 142
Differential Effects of 2-4D Weed
Killer 144
Ethylene, a Gaseous Hormone 144
Preparation of Materials 145

Chapter **16** Simple Invertebrate Animals 146

Objectives 146
Scypha, a Simple Sponge 146
Other Sponges 148
Hydra 148
Other Cnidaria 150

Chapter **17** The Worms 151

Objectives 151
Planaria 151
Other Flatworms 154
Ascaris 154
Other Round Worms 156
The Earthworm 156
Other Segmented Worms 160

Chapter **18** Animals with Jointed Legs 161

Objectives 161
The Crayfish 161
The Grasshopper 165

Chapter **19** Spiny-Skinned and Soft-Bodied Invertebrates 168

Objectives 168
The Starfish 168
Other Echinoderms 171
The Freshwater Clam 171
Other Mollusks 173

Chapter **20** The Chordates 175

Objectives 175
The Lancet, Amphioxus 175

The Lamprey 176
The Dogfish Shark 177
The Perch 178
The Living Frog 179
Histology of Some Frog Tissue 190
Study of Living Nerve and Muscle
Reactions in the Frog 191
Factors Affecting the Heartbeat of
the Frog 193
Preparation of Materials 194

Chapter **21** Human Skeletal and Muscular Systems 195

Objectives 195
Histology of Bone and Cartilage
195
The Human Skeleton 196
Some Human Muscle Reactions
199

Chapter **22** The Nervous System 201

Objectives 201
Structure of a Nerve Cell 201
Structure of the Brain 202
The Senses 203

Chapter **23** The Circulatory System 210

Objectives 210
The Blood 210
Anatomy of the Mammal Heart 217

Chapter **24** Respiratory, Digestive, and Excretory Systems 218

Objectives 218
Anatomy of Respiratory System
218
Homeostatic Regulation of
Respiratory Reactions in the Human
Body 220
The Anatomy of the Digestive
System 223
The Anatomy of the Mammal Kidney
225

Hormone-Induced Response of
Stems to Light and Gravity 139
Hormone Stimulation of Root Growth
141
Effect of Gibberellic Acid on
Seedling Growth 142
Differential Effects of 2-4D Weed
Killer 144
Ethylene, a Gaseous Hormone 144
Preparation of Materials 145

Chapter **16** Simple Invertebrate Animals 146

Objectives 146
Scypha, a Simple Sponge 146
Other Sponges 148
Hydra 148
Other Cnidaria 150

Chapter **17** The Worms 151

Objectives 151
Planaria 151
Other Flatworms 154
Ascaris 154
Other Round Worms 156
The Earthworm 156
Other Segmented Worms 160

Chapter **18** Animals with Jointed Legs 161

Objectives 161
The Crayfish 161
The Grasshopper 165

Chapter **19** Spiny-Skinned and Soft-Bodied Invertebrates 168

Objectives 168
The Starfish 168
Other Echinoderms 171
The Freshwater Clam 171
Other Mollusks 173

Chapter **20** The Chordates 175

Objectives 175
The Lancet, Amphioxus 175

The Lamprey 176
The Dogfish Shark 177
The Perch 178
The Living Frog 179
Histology of Some Frog Tissue 190
Study of Living Nerve and Muscle
Reactions in the Frog 191
Factors Affecting the Heartbeat of
the Frog 193
Preparation of Materials 194

Chapter **21** Human Skeletal and Muscular Systems 195

Objectives 195
Histology of Bone and Cartilage
195
The Human Skeleton 196
Some Human Muscle Reactions
199

Chapter **22** The Nervous System 201

Objectives 201
Structure of a Nerve Cell 201
Structure of the Brain 202
The Senses 203

Chapter **23** The Circulatory System 210

Objectives 210
The Blood 210
Anatomy of the Mammal Heart 217

Chapter **24** Respiratory, Digestive, and Excretory Systems 218

Objectives 218
Anatomy of Respiratory System
218
Homeostatic Regulation of
Respiratory Reactions in the Human
Body 220
The Anatomy of the Digestive
System 223
The Anatomy of the Mammal Kidney
225

Chapter **25 The Reproductive System 226**

Objectives 226
The Male Reproductive Organs 226
Human Sperm 227
Cross Section Through Seminiferous Tubule 228
The Female Reproductive Organs 229
Cross Section Through a Human Ovary 230
The Human Placenta 231
The Wharton Jelly Cells 232
Demonstration of Gonadotropic Hormone in Pregnancy Urine 232

Chapter **26 Mendelian Principles of Heredity 234**

Objectives 234
Albinism in Corn, a Monohybrid Cross 234
A Dihybrid Cross in Corn 236
A Monohybrid Cross in *Drosophila* 239

Chapter **27 Genes in Populations 241**

Objectives 241
Human Genes in a Population 241
Human Genetic Individuality 245
Probability in Human Inheritance 247
Determining Gene Frequencies in a Population 248
Effect of Selection on Gene Frequency 248
Genetic Drift, the Founder Principle 251

Chapter **28 Development of the Chordate Embryo 252**

Objectives 252
Early Embryogenesis of *Amphioxus* 252
Embryogenesis of the Frog 253
Development of the Chick Embryo 255
Demonstration of Human Embryos 255

Chapter **29 Behavior 256**

Objectives 256
Behavior in Microorganisms 256
Tactic Responses in *Drosophila* 258
Schooling Instinct in Fish 259
Preparation of Materials 260

Chapter **30 Solving a Biological Problem 261**

Objectives 261
Selection of a Problem 261
Search of the Literature 261
Progress of the Investigation 262
Report on Findings 262
Oral Presentation of Results 263

Chapter **31 Biological Etymology 267**

Prefixes 267
Suffixes 269
Derivation of Biological Terms 270

Glossary 271